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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003905176 for a patent by WATERPOWER SYSTEMS PTY LTD as filed on 23 September 2003.

I further certify that the name of the applicant has been amended to AQUENOX PTY LTD pursuant to the provisions of Section 104 of the Patents Act 1990.

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Seventh day of October 2004

J. Billingsley

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
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PROVISIONAL SPECIFICATION

Invention Title: "WASTEWATER PURIFICATION METHOD"

The invention is described in the following statement:

TITLE

WASTEWATER PURIFICATION METHOD

FIELD OF INVENTION

This invention is concerned with a method and apparatus for purifying water waste streams such as that from public and domestic showers, baths and wash basins, launderettes, restaurants, vehicle garages including vehicle service facilities and car washes, hotels, ships and aeroplanes. In particular, the invention relates to a method of purifying and recycling wastewater for human re-use.

BACKGROUND OF THE INVENTION

Water is an invaluable commodity and most regions of the world are faced with a limited resource of fresh, consumable water. Therefore treatment and recycling of wastewater is an increasingly essential utility worldwide and in conditions where water is at a premium, such as geographical areas that have very little rainfall, ships and aeroplanes, water recycling is essential.

Water restrictions are frequently imposed on domestic users and commercial institutions by the government. In situations of water shortage the water supply may only be available for one to two hours a day. However, even if sources of fresh water are readily available, water conservation and recycling are ecologically preferred options and also provide substantial cost benefits.

There are many industries that produce large amounts of wastewater, such as industrial launderettes, hotels, cruise ships, aeroplanes,

petrochemical industry and hospitals. Such wastewater would contain contaminants such as detergents, oils, greases, suspended matter, petrochemicals, biological and non-biological organic compounds and food and beverage waste

US Patent Number 4,812,237, in the name of Cawley and Mercer, describes a water purification and recycling system for processing domestic wastewater. The system comprises septic tanks, a sand filter, an ultrafilter, a disinfection unit and water quality and quantity sensors to monitor and control the process. This system is designed for domestic use and relatively small amounts of water, and the water would take a long time to pass through the system. Therefore it is not suitable for large amounts of wastewater that have to be purified rapidly, for example in a commercial situation, such as a hotel, hospital or commercial car wash.

US Patent Number 5,147,532, in the name of Kenneth Leek, also describes a water purification system for wastewater from domestic appliances. This is also a complicated system comprising screen, sediment, carbon and colour filters, an ultraviolet radiation unit and a storage tank. This system is designed for domestic and not commercial use and would not efficiently process thousands of litres of water.

US Patent Number 4,802,991, in the name of George Miller, describes a water purification process particularly suitable for purifying water containing fatty acids. The purification apparatus comprises an inlet conduit, electrolysis chamber, flocculation chamber and a monitoring device. The flocculation chamber has a conical shape and is located directly above the

electrolysis chamber and is in direct contact with the electrolysis chamber. The electrolysis and flocculation chambers comprise a moving bed of solid non conductive particles, such as granite, having a specific density greater than that of the water to be purified. The wastewater is passed upwards through the electrolysis chamber and the moving bed of particles, past the electrodes into the flocculation chamber. As the water passes into the flocculation chamber the moving bed of particles falls back into the electrolysis chamber past the electrodes under the force of gravity. This allows efficient and constant self-cleaning of the electrodes. The monitoring device monitors the degree of pollution of the wastewater and comprises a light source and sensor which reactions to variations in water turbidity.

This type of purification system is not suitable for treating wastewater comprising particles or a high grease or oil content. The particles or thick oil would become trapped in the moving bed of particles, which would prevent efficient purification of the water. In addition most electrocoagulation or electrolysis systems have more sophisticated methods of cleaning the electrodes and therefore there is no need for a moving bed of particles.

It is therefore an object of the invention to provide a purification process for water that may alleviate the disadvantages over the prior art.

SUMMARY OF INVENTION

In a first aspect, the invention provides a method of purifying grey water that includes the steps of:

(i) passing wastewater through an electrocoagulation cell which comprises a plurality of reaction plates disposed within said cell

and spaced apart from each other wherein at least two of said plates are electrically connected to a power supply, whereby the current and voltage applied to said plates may be dependent on any one of the following: (a) the conductivity of the wastewater (b) the flow rate of wastewater through said cell and (c) the number of reaction plates that are electrically connected and (d) the amount of suspended solids and/or concentration of dissolved metal cations in the wastewater; and

(ii) collecting the purified water.

Prior to step (i) the wastewater may be obtained from public or household showers, sinks, basins, baths, washing machines, dishwashers, kitchens or car washes and may be initially stored in a collection tank or sump.

In step (i) the wastewater is pumped through a suitable conduit or hose into the electrocoagulation system reaction chamber which in use may not contain any solid material with the exception of solids in the wastewater and thus will not employ any moving bed of particles as described, for example, in US Patent No. 4,802,991 described above. Suitably, the wastewater may be filtered prior to electrocoagulation treatment to remove large particles from the wastewater. Preferably, particles with a size greater than 200 μm are removed.

Preferably, the electrolytic reaction chamber is part of a conventional electrocoagulation cell as described in International Patent Application WO 01/53568 or US Patent 6,139,710. Preferably, direct current (DC) is applied to the reaction chamber. This has the advantage of using a smaller number

of electrodes than is the case of alternating current.

The electrocoagulation cell is preferably orientated vertically so that the outlet conduit is located at the top of the reaction chamber and the inlet conduit is located at the bottom of the reaction chamber. However, this does not preclude the use of an electrolytic cell arranged horizontally, such as described in, for example, WO 96/28389 or in US Patent No. 5,611,907. It is also possible for the water to be circulated throughout the cell in a serpentine fashion in either a vertical or horizontal orientation.

The electrolysis cell may comprise any number of electrodes or reaction plates but at least two are used which are electrically coupled to the power supply. The total number of electrodes used can be calculated depending on the total wetted surface area of electrodes in the cell, the number of electrodes electrically connected to a power source, the gap between the electrodes, and the flow rate, conductivity and cell residence time of the solution. Preferably, each side of the electrode plate is contacted by water.

The voltage and current values are calculated depending on the conductivity of the wastewater, flow rate through the cell, number of electrodes electrically connected to the power source and the amount of suspended solids and/or dissolved metal cations in the wastewater.

Preferably, the voltage applied to the cell falls within the range 20-60 volts.

Preferably, the current applied to the cell falls within the range 2-15 amps.

The reaction plates can be manufactured from aluminium, steel or iron. Preferably, aluminium reaction plates are used. Also 2-60 reaction plates in the electrolysis cell can be used. Of these reaction plates, 2-20 may be connected to the power supply. Preferably, 2-8 reaction plates are connected.

Preferably, a flow rate of 2-1000 L/min is used. More preferably, a flow rate of 5-200 L/min and even more preferably 10-50 L/min is used.

The purified water is discharged into one or a plurality of settling tanks for separation of the contaminated floc from the purified water. The settling tanks can be connected to a rainwater collection tank to allow collected rainwater to be discharged into the settling tanks to increase the volume of water available for recycling.

Suitably, the purified water is filtered prior to re-use. Preferably, particles with a size greater than 10 μm are removed.

In step (ii) the purified water can be stored in a storage tank before re-use. After re-use the water may be collected and stored in the collection tank or sump. Preferably, the water purification system is a closed system that recycles the same water.

Throughout this specification, "comprise", "comprises" and "comprising" are used inclusively rather than exclusively, will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference may now be made to a preferred embodiment of the

invention as shown in the attached drawings wherein:

FIG. 1 is a schematic drawing of a water purification plant showing the process steps that can be applied to wastewater from a car wash.

Fig. 2 is a schematic drawing showing an electrolysis electrode configuration and its connection to a power supply.

DETAILED DESCRIPTION OF INVENTION

For the purposes of this invention, by "wastewater" is meant any type of grey water obtained from car washes and commercial and domestic washing machines, dishwashers, showers, baths and sinks.

The wastewater may contain contaminants such as, suspended solids, oils, grease, dissolved metals and detergents.

Fig. 1 shows a schematic drawing of water purification plant 1 which may be applied to wastewater obtained from a car wash.

Water from sump 2 is transferred or pumped through conduit 3 into filter 4. Filter 4 removes suspended particles with a size greater than 200 μm. The solids from the filter underflow are collected and disposed through conduit 4A.

The liquid overflow from filter 4 is transferred through conduit 7 into electrolysis cell 5. Pump 3A can create variable flow rates of water into electrolysis cell 5. Electrolysis cell 5 comprises a plurality of reaction plates 6.

After electrolysis treatment in electrolysis cell 5, the water is discharged through conduit 8 into settling tank 9. The overflow of froth and oil can drain through conduit 10, which is preferably located in the top of tank

9. The overflow is disposed through conduit 10A. Rainwater collected in collection tank 11 may also be transferred through conduit 11A into settling tank 9.

The water may then be transferred into settling tank 13 through conduit 12 and then into settling tank 16 through conduit 15. Settling tanks 13 and 16 may also have an overflow conduit (not shown) to allow any remaining froth or oil to be discharged.

The water is then pumped by pump 18 through conduit 19 to filter 20. Filter 20 removes suspended particles with a size greater than 10 μm. The solids from the filter underflow are collected and disposed through conduit 21.

The liquid overflow from filter 20 is transferred through conduit 22 into storage tank 23. Storage tank 23 may comprise ball valve control 24 which controls water inflow and outflow of tank 23. The purified water is transferred to the car wash water supply pipes through conduit 25. The water can be ejected through high-pressure gun 26 onto the vehicle to be washed.

Dirty wastewater is then collected through a drainage system located beneath the parked vehicle (not shown) and channelled into collection conduit 27. Conduit 27 transfers the wastewater into sump 2 for recycling through water purification plant 1.

FIG. 2 shows an electrolysis electrode (reaction plate) configuration 30 and its connection to a power supply 31. There are 25 flat plate electrodes in total; nine unipolar electrodes 32 that are connected to DC power supply 31 and sixteen bipolar electrodes 33. An electric current is

passed through the water in electrolysis cell 5 to induce an electrochemical reaction occurs whereby metal ions released from the electrodes and water anions released from the water cause coagulation in the wastewater and destabilize colloidal suspensions from aqueous solutions. The floc binds or absorbs other impurities present in the wastewater and serves as a transport medium to remove impurities from the water.

A description of an electrocoagulation cell is provided in International Patent Publication No. WO 01/53568 and US Patent No. 6,139,710. The precipitation or suspension (floc) can be removed through separation techniques, such as sedimentation, filtration or electrolytic flotation.

Electrodes are connected to the DC power source via suitable cables and a bus bar arrangement 31, which is bolted directly onto each unipolar electrode 32 by bolts 34. For effective purification of the wastewater, an optimum current and voltage may be applied via the electrodes to the water. The current and voltage values are dependent on the following critical parameters;

(i) number of electrodes used;

(ii) total wetted surface area of electrodes in the cell;

(iii) number of electrode connections to a DC power source;

(iv) size of the gap between the electrodes;

(v) pH of the water;

(vi) conductivity of the water;

(vii) the concentration and types of contaminants in the wastewater; and

(viii) flow rate and cell residence time of the water through the cell.

Preferably, the conductivity of the wastewater is measured before the process is set up and conductivity variations are measured regularly throughout use of the process. Preferably, the electrocoagulation cell parameters are set up taking into consideration the minimum conductivity value. Conductivity variations for car wash wastewater are typically very low. However, the conductivity of laundry or dishwashing wastewater can vary considerably and therefore conductivity values should be measured more regularly.

The optimum parameters can be determined experimentally by a skilled person. If a fixed water flow rate is used, a critical factor in determining the current and voltage values is the cell configuration, i.e. the number of electrodes in the cell, the gap between the electrodes and the number of electrodes that are connected to a DC power source. Preferably, parameters such as the flow rate, number of electrodes in the cell, the size of the gap between the electrodes and the number of electrodes that are connected to a DC power supply will be fixed. Preferably, the reaction plates extend across the width or length of electrolysis cell 5 and each side of the electrode is contacted by the water to allow maximum contact with the water flowing through the cell (total wetted surface area of cell).

Preferably, if a low flow rate is used (2-20 L/min), a smaller cell design with a lower number of electrodes and less total power (voltage and current) is required. If a high flow rate is used (1000 L/min), a larger cell design with greater than 20 electrodes is required, more preferably 50-60 electrodes.

Other important factors are the linear velocity of the solution through the cell and the cell residence time. Cell residence time depends on the flow rate of water through electrolysis cell 5 and the type of flow through cell 5, for example, laminar or serpentine flow. Preferably, the following characteristics of water flow through the cell are used:

(i) laminar flow;

(ii) linear flow velocity;

(iii) orientated solution entry at the bottom of the cell; and

(iv) solution output vertically above the solution entry point and at the top of the cell.

The power system controlling the electrocoagulation system may be automated to facilitate precise control and to provide flexibility in controlling electrolysis cell 5.

Preferably, purification plant 1 and associated power system is designed to be compact and portable to facilitate transport to and use in a variety of locations. Preferably, it can be mounted on ground engaging wheels or a skid, or even installed underground, for example, underneath a car wash or under a house. There also may be provided a generator for providing electrical power to power supply 14.

Filters 4 and 20 can be any type of filter, such as a belt press, sand or plate and frame type filters. Preferably, a filter media is used which is easily cleaned or replenished enabling minimal downtime of the system.

Valve 24 can be any type of check valve which incorporates a biasing member such as a spring which when biased away from a valve seat opens

a valve orifice located in a valve chamber for passage of fluid. The spring is usually associated with a movable valve member such as a ball. Alternatively a swing and lift valve may be used.

Preferably, if an electrocoagulation cell comprises 8-50 electrodes with a gap of 3 mm between each electrode and 2-25 electrode connections to a DC power source, the voltage applied to the electrocoagulation cell falls within the range 20-80 volts (DC) and the current may fall within the range of 5-150 amps. These values will of course be dependent upon the varying characteristics of the sample matrix of the wastewater.

The wastewater may remain in settling tanks 9, 13 and 16 for a variable amount of time. Preferably, the wastewater remains in each tank for 20-60 minutes, more preferably, 30-40 minutes.

Preferably, no chemicals are used in the process. However, it may be necessary to add chemicals for (i) conductivity modification or standardisation; (ii) for pH control (in cases of high or low pH wastewater); and (iii) addition of poly-electrolyte solutions to the wastewater after electrocoagulation treatment in settling tanks 9, 13 and 16 to accelerate contaminant coagulation.

Modifications may be made to the purification process. Any of the pre-treatment or post-treatment steps may be omitted subject to the nature or composition of the wastewater.

While the invention has been described with the particular reference to a purification process for wastewater obtained from a car wash it will be understood that, in a modified form, the invention may also be used for the

purification of water obtained from washing machines, dishwashers, showers, baths and sinks from domestic homes, hotels, restaurants, ships, aeroplanes or hospitals. Different voltage and current values and different electrolysis cell design may be required for effective water purification depending on the composition of the wastewater and the flow rate of the wastewater through the system.

Used grey water from one or a plurality of washing machines, dishwashers, sinks or showers can be collected in conduit 27 and transferred to sump 2. The grey water can then be purified as described above and is stored in storage tank 23 before being recycled through conduit 25 to one or a plurality of the abovementioned washing machines or water outlets.

So that the invention may be more readily understood and put into practical effect, the skilled person is referred to the following non-limiting examples. Each of these examples uses a closed system as shown in FIG. 1.

EXAMPLES

Example 1

The following example applies to an EC system for the removal of shower and washbasin contaminants from a wastewater sample.

Contaminants present in sample - suspended solids (dirt), TP (total phosphorous - detergents)

The sample was grey-coloured water with soap suds and dirt in solution. There were some suspended particles and the sample was stirred sample stirred while treated.

The raw sample had a pH of 5.4 and conductivity 780 µS/cm.

Flow rate: 1L/min

Experimental results

The most successful treatment was achieved using the following parameters:

Electrode type: Aluminium

Number of electrodes = 8

Number of connections = 4 (1, 3, 6, 8)

Volts = 35

Amps = 4.8

Coagulant produced - light density foam coagulant and a very clear aqueous layer. Very effective removal of dirt and detergents was observed.

Water re-cycling is an option for the treatment process.

The sample was treated without any adjustment of pH or conductivity.

Example 2

The following example applies to an EC system for the removal of restaurant discharge contaminants (food and fats) from a wastewater sample.

Contaminants present in sample - suspended solids, total phosphorous (TP - detergents), food, oil and grease (cooking oils), BOD (biological oxygen demand - food proteins), total Kjeldahl Nitrogen (TKN - nutrients).

The sample was grey/brown-coloured water with food particles in solution.

Preferably, the sample is pre-filtered prior to treatment.

The raw sample had a pH of 5.5 and conductivity 1,150 µS/cm.

Flow rate: 1L/min

Experimental results

The most successful treatment was achieved using the following parameters:

Electrode type: Aluminium

Number of electrodes = 8

Number of connections = 4 (1, 3, 6, 8)

Volts = 50

Amps = 9.5

Coagulant produced - high density/ large volume foam coagulant due to the high BOD content. Fats and greases were also removed. There was a very clear aqueous layer. Method was highly successful.

Water re-cycling is an option for the treatment process.

The sample was treated with an adjustment to pH. The conductivity was high due to food salts in the sample.

Example 3

The following example applies to an EC system for the removal of engine oil contaminants from a wastewater sample from a car service facility.

Contaminants present in sample – suspended solids, TP (detergents), car oil and grease (engine oils), petrochemicals and dissolved metals.

The sample was a brown/black emulsion, oil/grease emulsion with dirt and detergents in solution.

The raw sample had a pH of 6.8 and conductivity 490 µS/cm.

Flow rate: 1L/min

Experimental results

The most successful treatment was achieved using the following parameters:

Electrode type: Aluminium

Number of electrodes = 8

Number of connections = 4 (1, 3, 6, 8)

Volts = 51

Amps = 3.0

Coagulant produced - high density/ low volume coagulant

Oils and greases, dirt and other components were removed.

There was a very clear aqueous layer. Therefore the method was successful

Water re-cycling is an option for the treatment process.

The treatment method works across a broad range of pH and conductivity.

Example 4

The following example applies to an EC system for the purification of drain water from trade waste.

Contaminants present in sample – oil, grease and suspended solids.

The sample was an oil/grease emulsion with dirt and detergents in solution.

The raw sample had a pH of 7.7 and conductivity 1260 μS/cm.

Flow rate was 1L/minute.

<u>Experimental results</u>

The most successful treatment was achieved using the following parameters:

Electrode type: Aluminium

Number of electrodes = 8

Number of connections = 4

Volts = 33

Amps = 11

Detergents, oils and greases, dirt and other components were removed.

Example 5

The following example applies to an EC system for the purification of water contaminated with oil.

Contaminants present in sample – oil

The sample was an oil/grease emulsion

The raw sample had a pH of 5.6 and conductivity 1090 μS/cm.

Flow rate was 1L/minute.

Experimental results

The following treatment was successful using the following parameters:

Electrode type: Aluminium

Number of electrodes = 8

Number of connections = 8

Volts = 10

Amps = 10

The oil was removed to leave a clear aqueous layer.

The advantages of the grey water purification process of this invention are as follows:

(i) the process allows the rapid treatment of large volumes of water;

(ii) the system is automated, compact and portable;

(iii) electrocoagulation separates rather than destroys wastewater contaminants and produces a low volume, aqueous stable sludge that is readily separated from a liquid stream for subsequent disposal;

(iv) minimal amounts of chemicals are used in the process;

(v) the process can perform effectively the simultaneous treatment of multiple contaminants; and

(vi) the process recycles and conserves water, drastically reducing the amount of water used; and

(vii) the process saves money by reducing water bills.

DATED twenty third day of September 2003

WATERPOWER SYSTEMS PTY LTD

by its Patent Attorneys

FISHER ADAMS KELLY

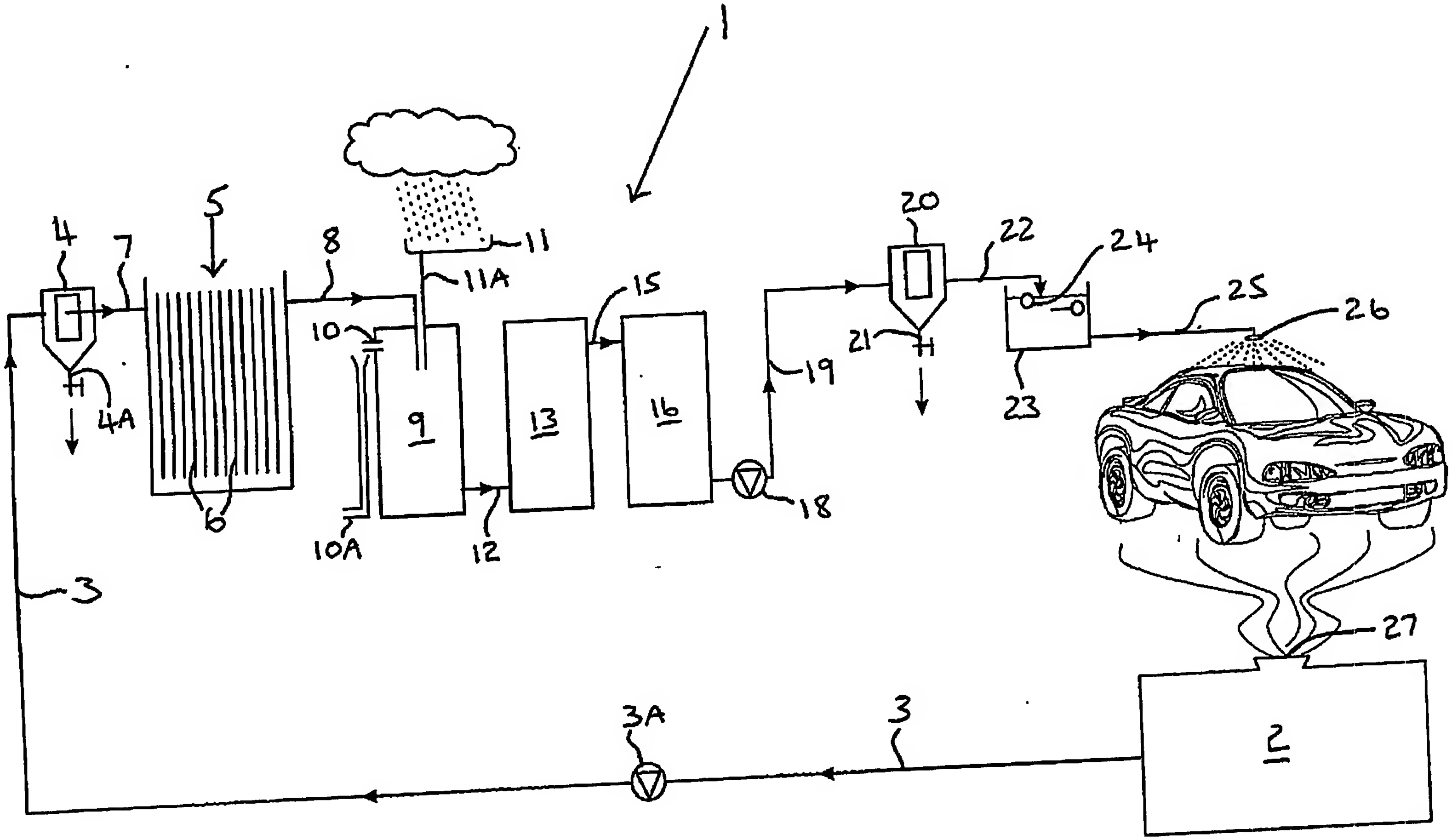

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FIG. 1

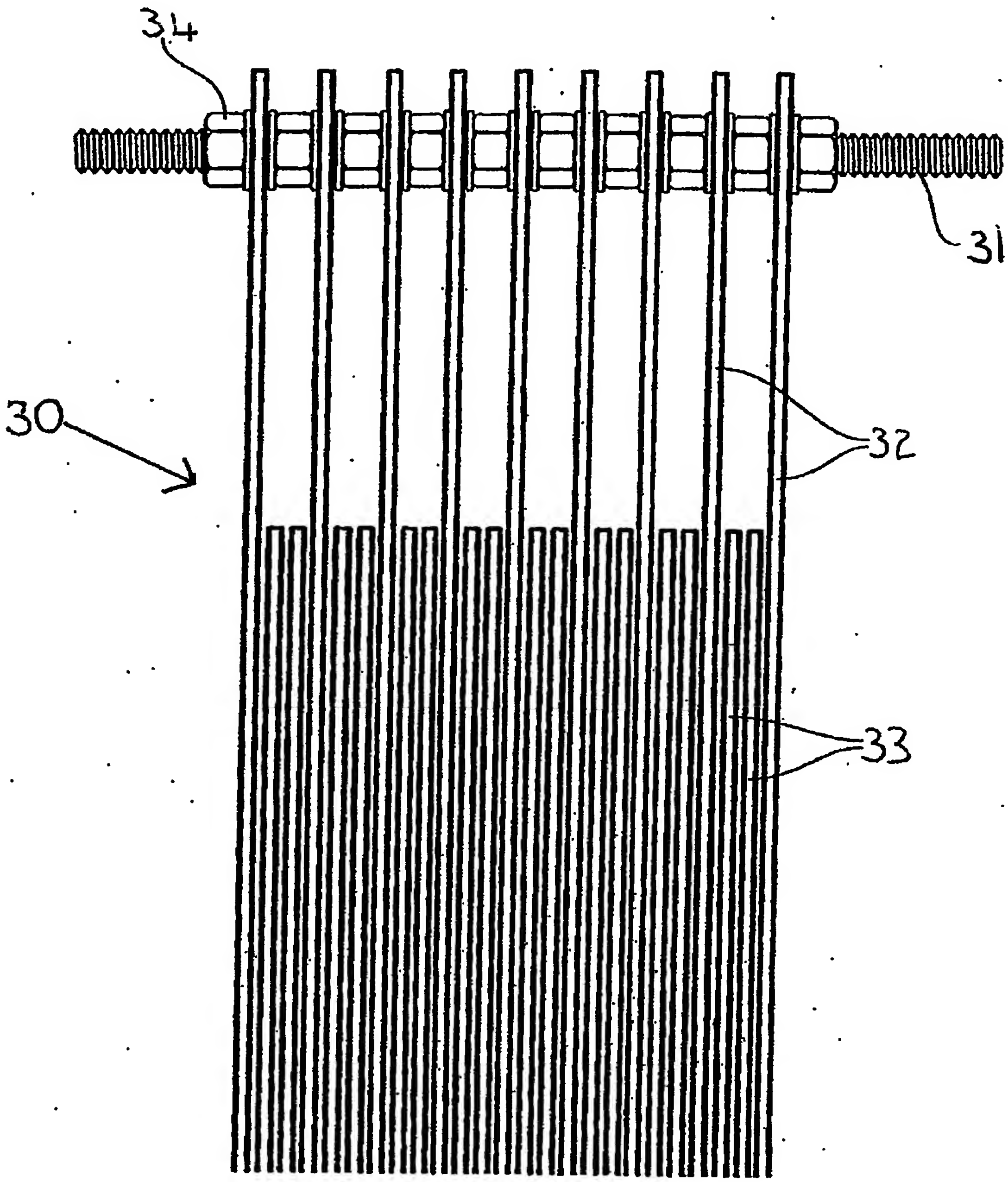

FIG. 2